Other charmonium(-like) states at Belle

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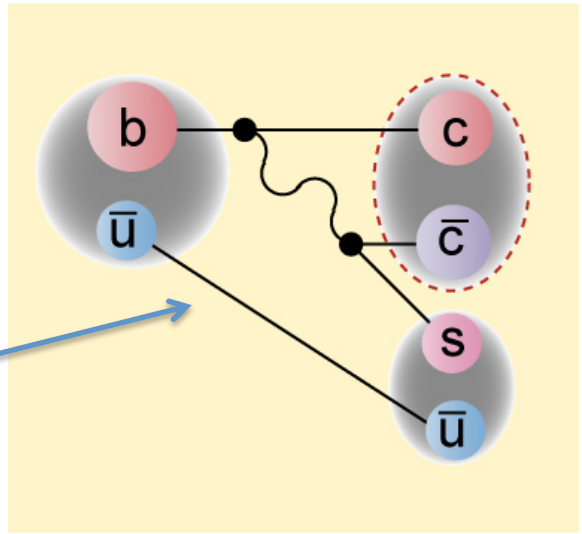
$(c\bar{c})$-like states in $J/\psi\omega$ and $J/\psi\phi$

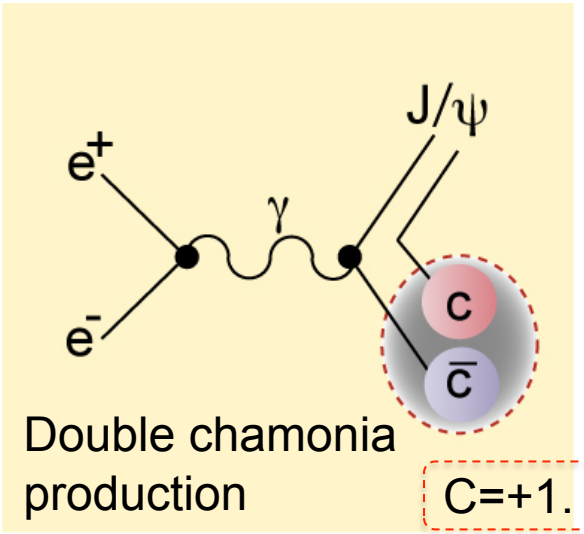
- Question : Is the same particle observed in the different production processes?
  - "Yes" or "No", either provide very important information to determine/confirm its quantum numbers.
- Enhancement in M($J/\psi\ \omega$) just above threshold.
  - Remind $B\rightarrow J/\psi\ \omega$ K decays at Belle, BaBar.
  - $J/\psi\ \omega$ in $\gamma\gamma$ collision at Belle
- Enhancement in M($J/\psi\ \phi$) just above threshold.
  - Remind $B\rightarrow J/\psi\ \phi$ K decays at CDF, Belle.
  - $J/\psi\ \phi$ in $\gamma\gamma$ collision at Belle.
- Summary

At B-factories

There are various processes to produce charmonium(-like) particles.

In two-body B-decays, $J^{PC}=0^{-+}, 1^{--}, 1^{++}$ in factorization limit.

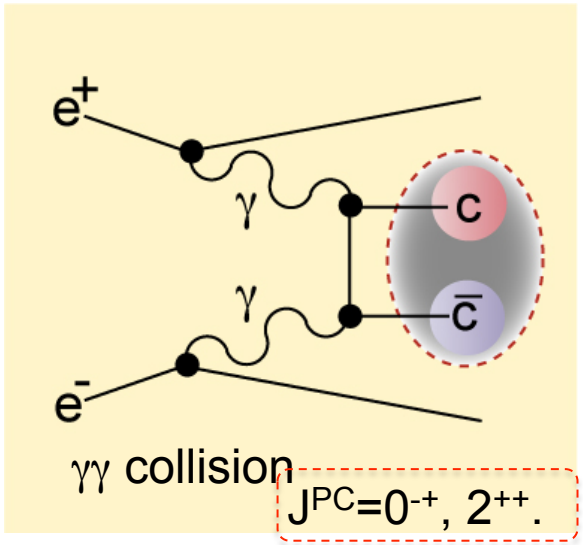




Double chamonia production

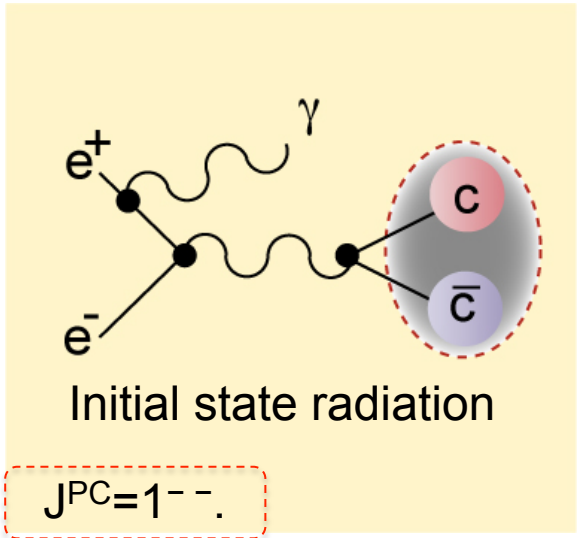
C=+1.

Allowed/favored quantum numbers are different depending on production processes.



γγ collision

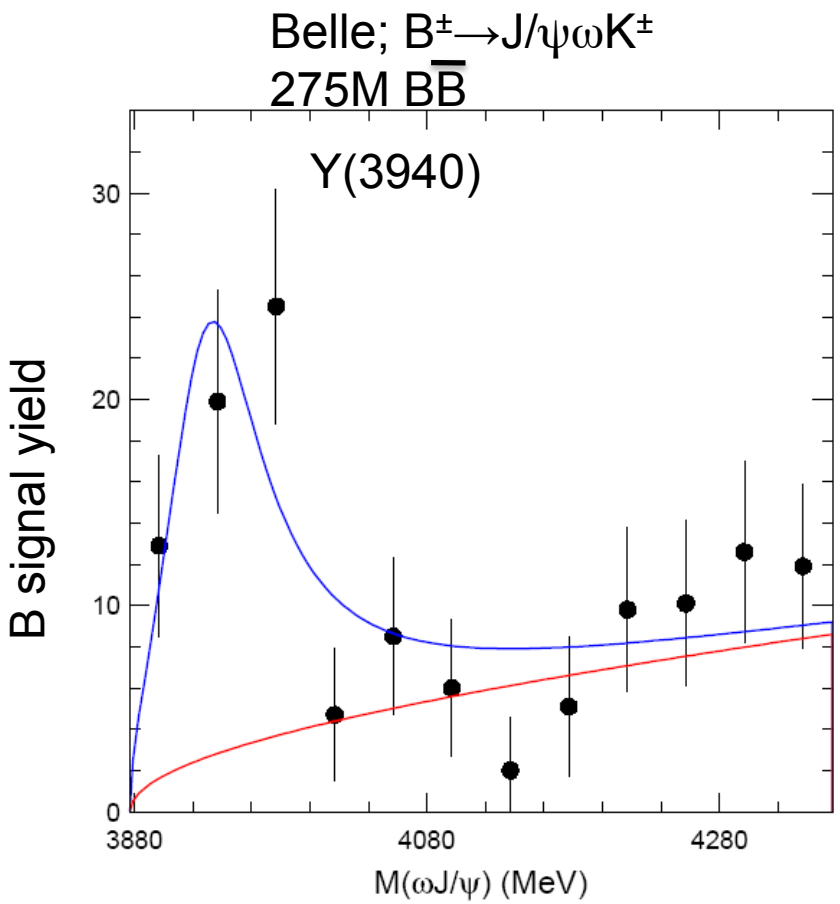
$J^{PC}=0^{-+}, 2^{++}$.



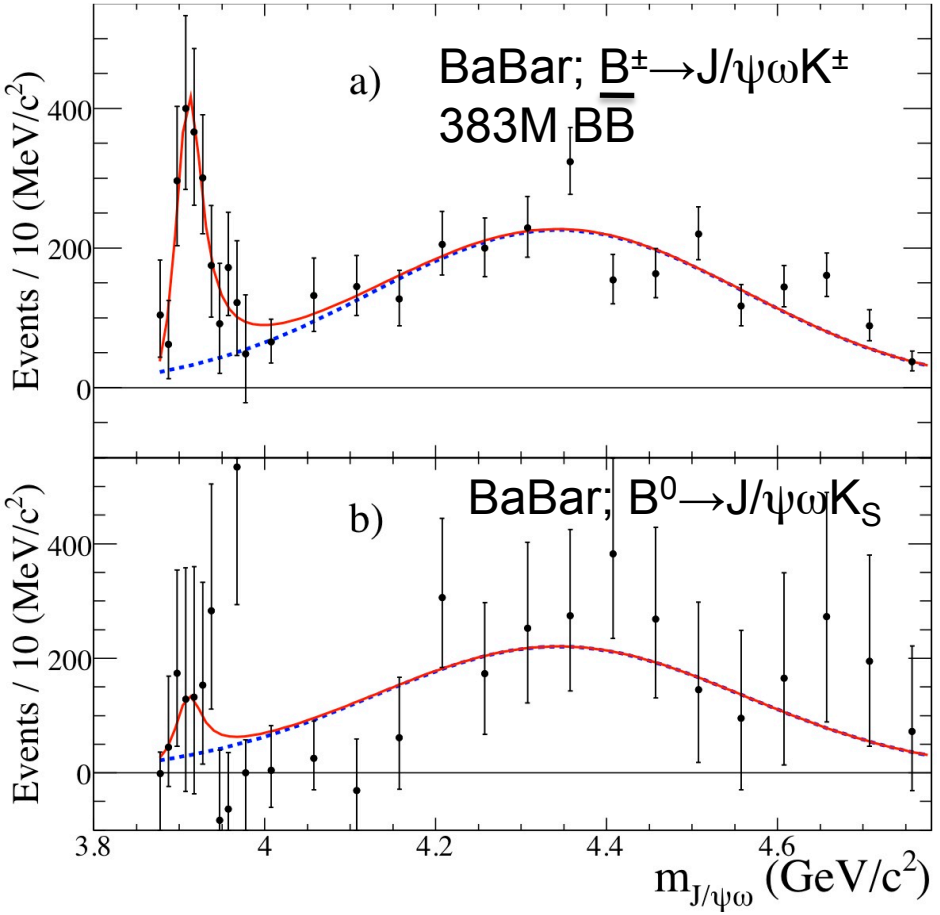
Initial state radiation

$J^{PC}=1^{--}$.

Y(3940) : Remind B→J/ψωK decays



M=3943±11(stat)±13(syst) MeV
Γ=87±22(stat)±36(syst) MeV
PRL94,182002(2005)

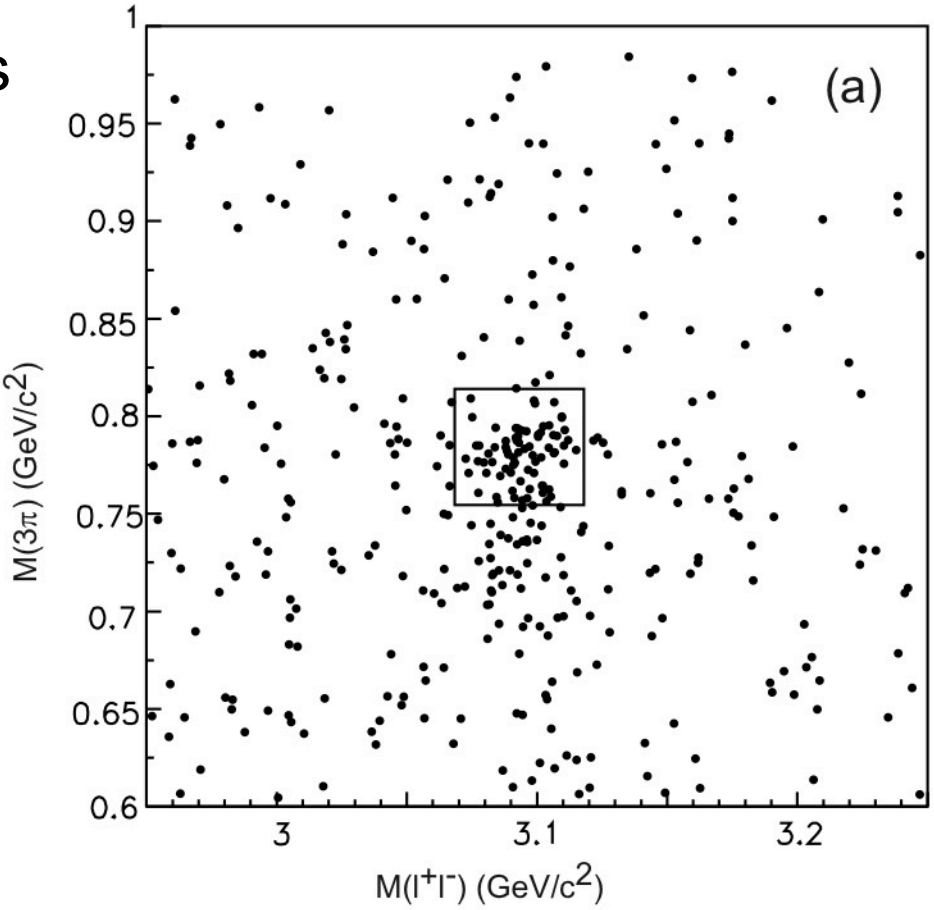


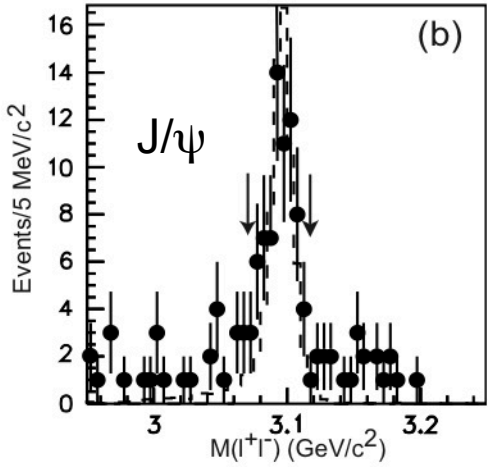
M=3914.6$^{+3.8}_{-3.4}$(stat)±2.0(syst) MeV
Γ=34$^{+12}_{-8}$(stat)±5(syst) MeV
PRL101,082001(2008)

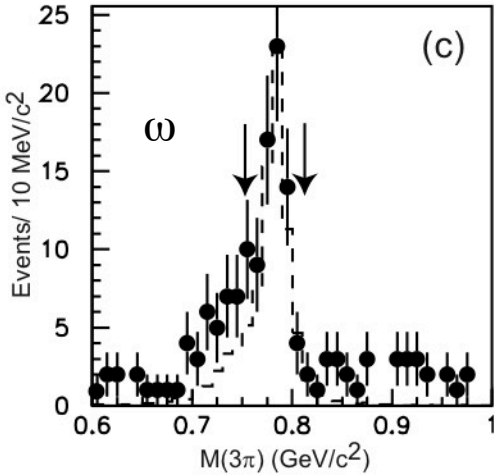
J/ψ ω in γγ at Belle

Candidate events are selected by;

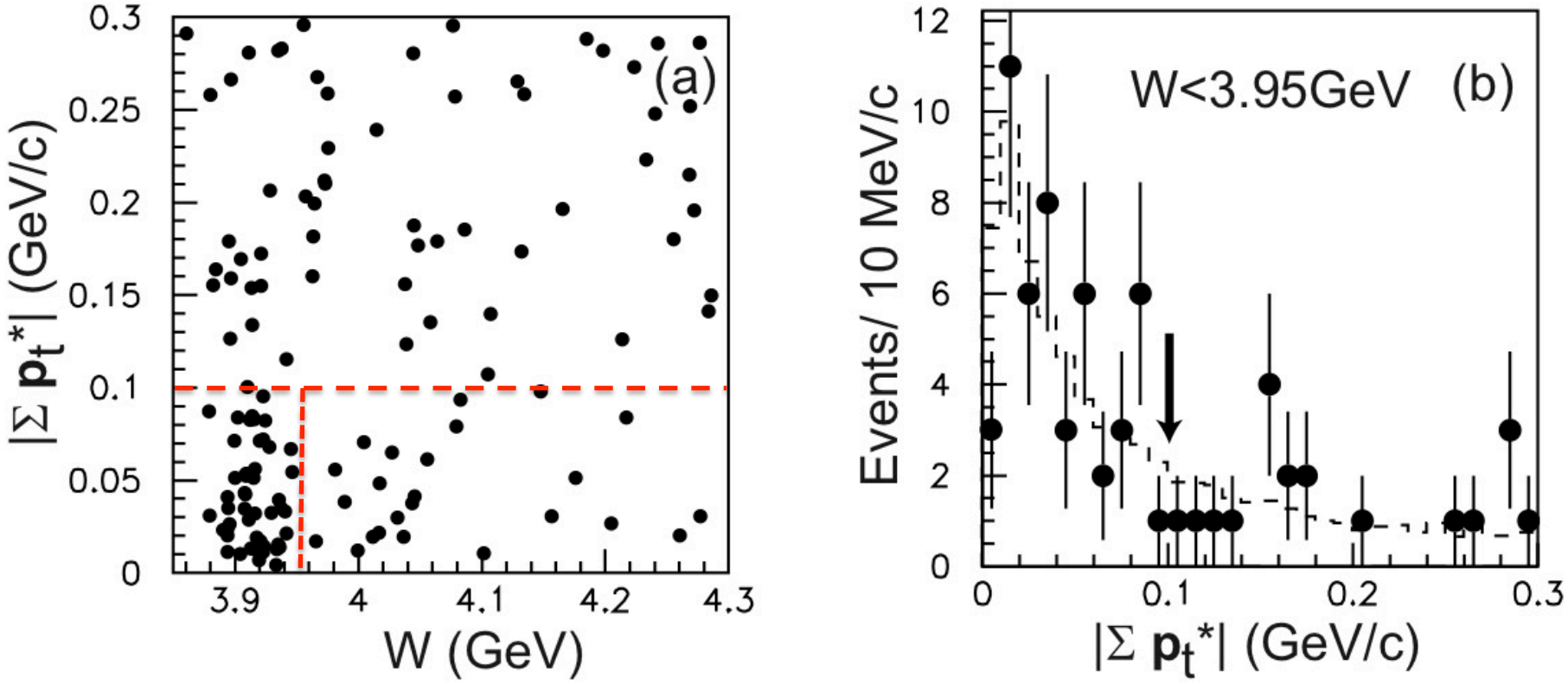
- Four tracks
- Net charge=0
- π^0 candidate
- Lepton ID
- K rejection
- P_t and P_z





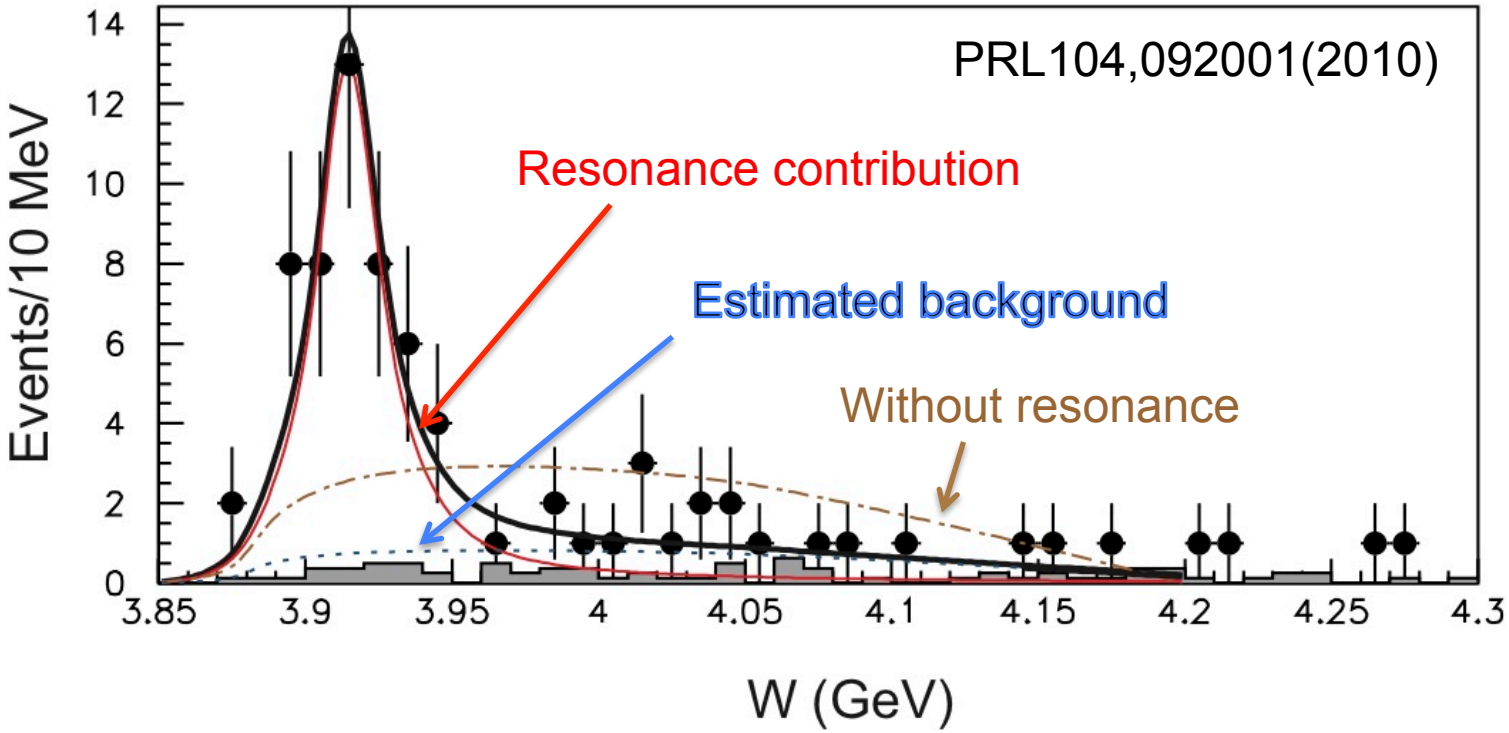


J/ψ ω in γγ at Belle (cont.)



In γγ collision signal region (P_t < 0.1GeV), an event concentration is seen at M(J/ψω) <3.95GeV!

M(J/ψ ω) in γγ (P_t < 0.1 GeV)



Clear enhancement seen just above J/ψ ω threshold!

Statistical significance=7.7σ, Signal=49±14(stat)±4 events.

M=3915±3(stat)±2(syst) MeV

Γ=17±10(stat)±3(syst) MeV

J^{PC} not yet determined (need much more statistics).

Enhancement in M(J/ψ ω)

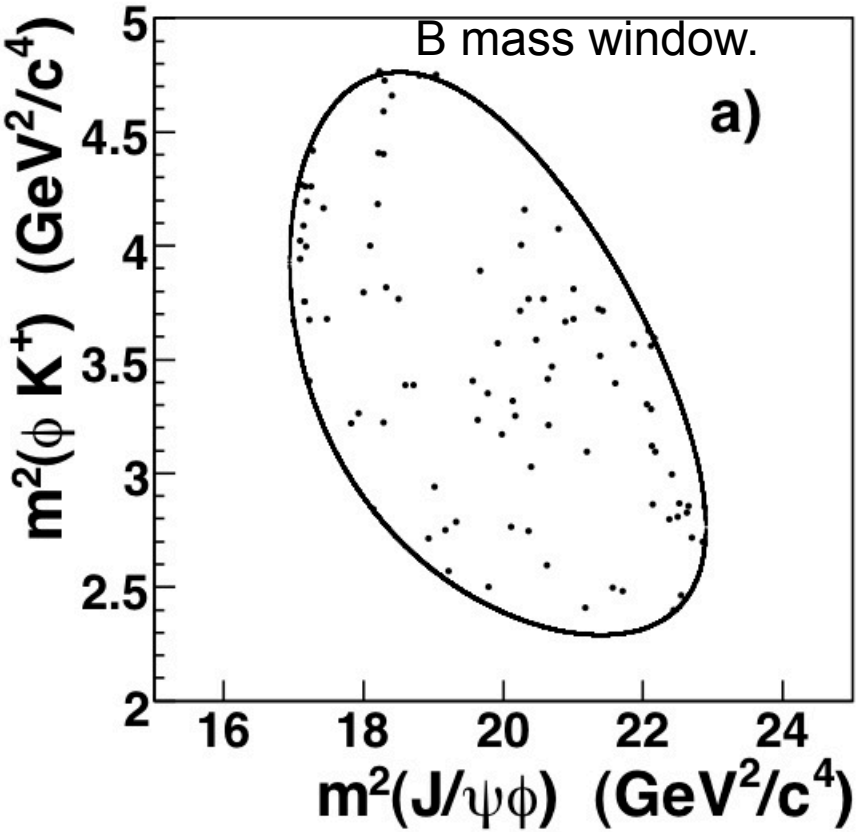
- Is it Y(3940) appearance in $\gamma\gamma$ collision?
- If yes, J^{PC} should be compatible, 0^{-+}, 2^{++}.
- Belle $B \to J/\psi\ \omega\ K$ published result with only 275M BB, now we have 772M BB!

$\rightarrow$ we will revisit this B decay final state soon.

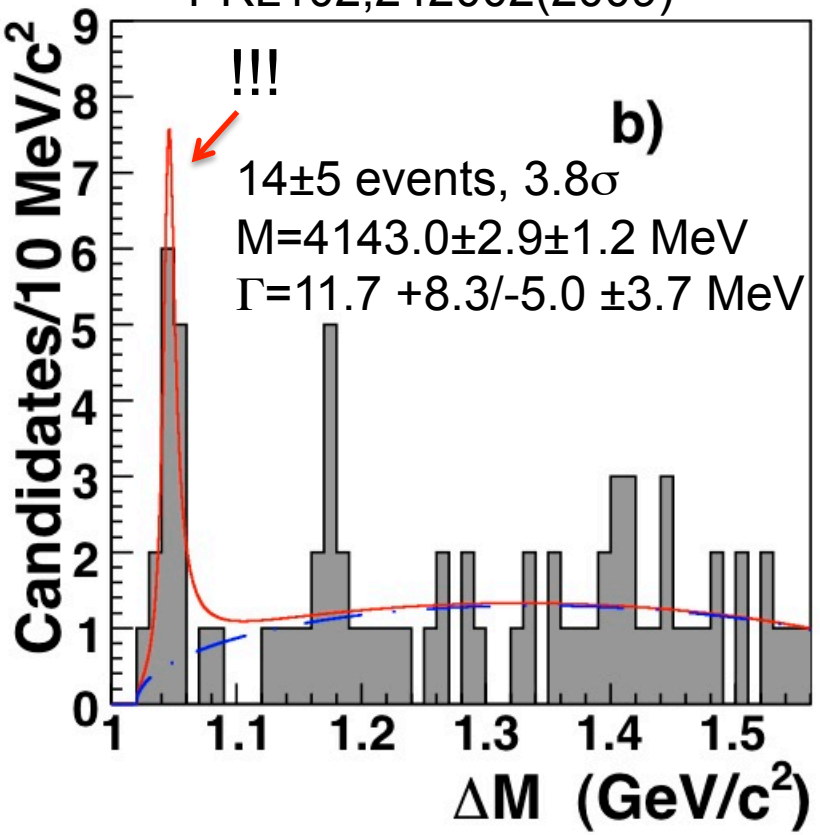
(More precise M, Γ determination, attempt to see J^{PC}.)

Y(4140) : Remind $B^{\pm} \to J/\psi\phi K^{\pm}$ decays

Dalitz distribution in B mass window.



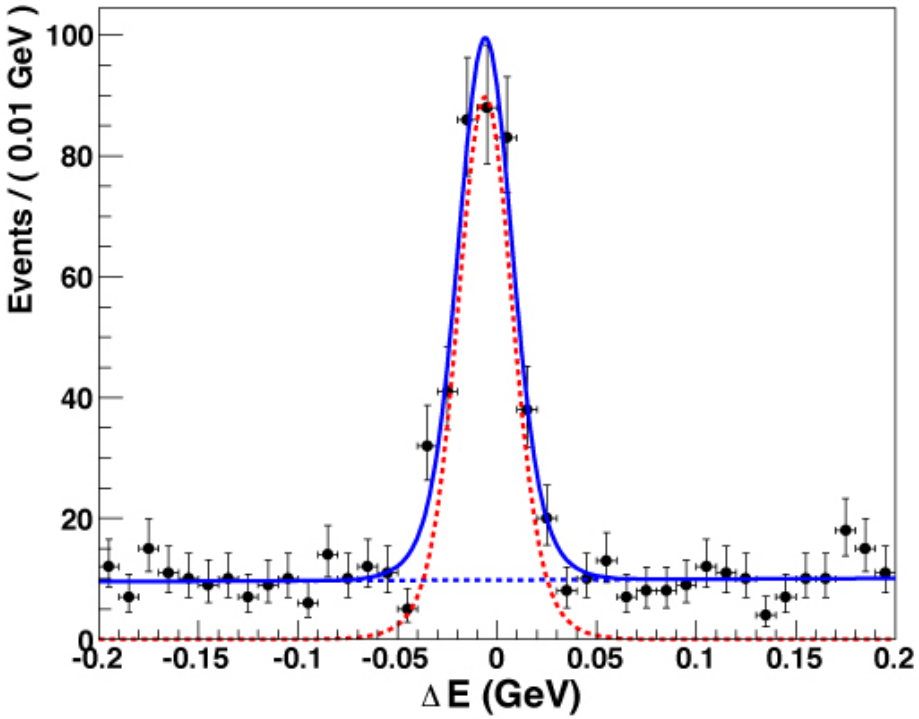
CDF: $B^+ \to J/\psi\phi K^+$, PRL102,242002(2009)

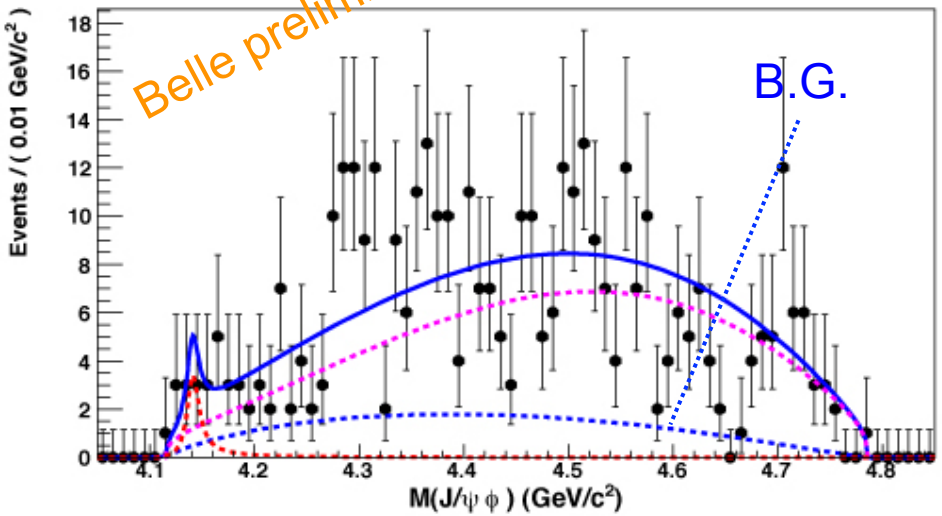


This resonance contains $\bar{c}\bar{c}ss$!?

$B^{\pm} \rightarrow J/\psi\, \phi\, K^{\pm}$ at Belle

$B^{\pm} \rightarrow J/\psi \phi K^{\pm}$
Signal : 325±21events

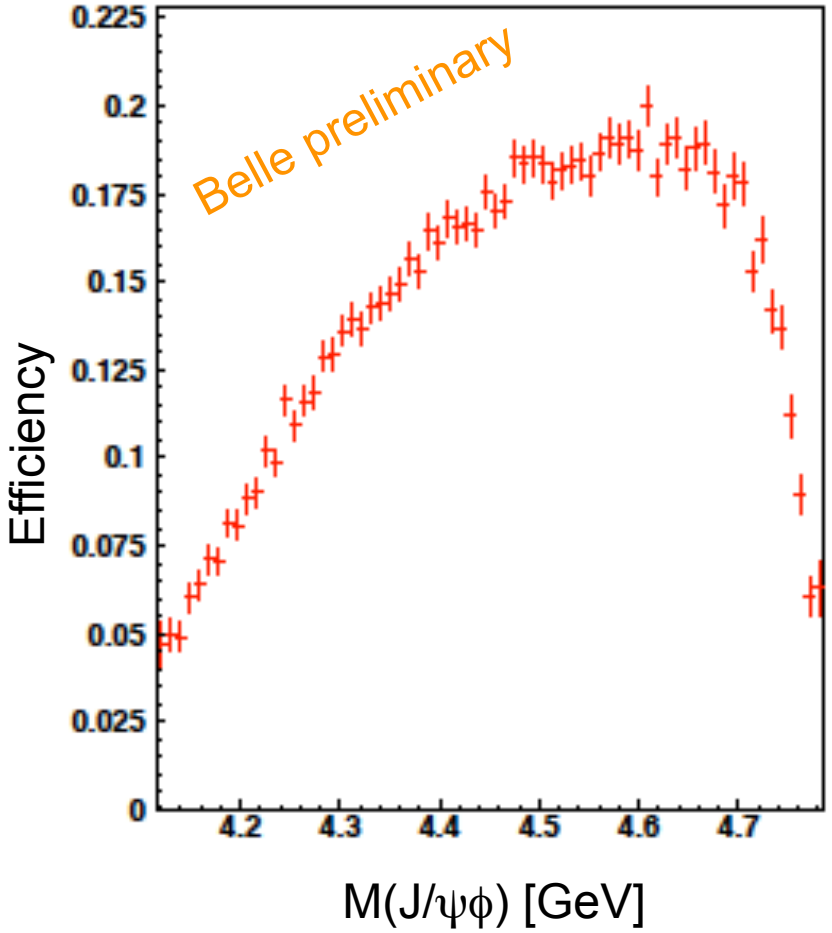




Y(4140) : 7.5 +4.9/-4.4events
Statistical significance : 1.9σ
Signal could not be identified.

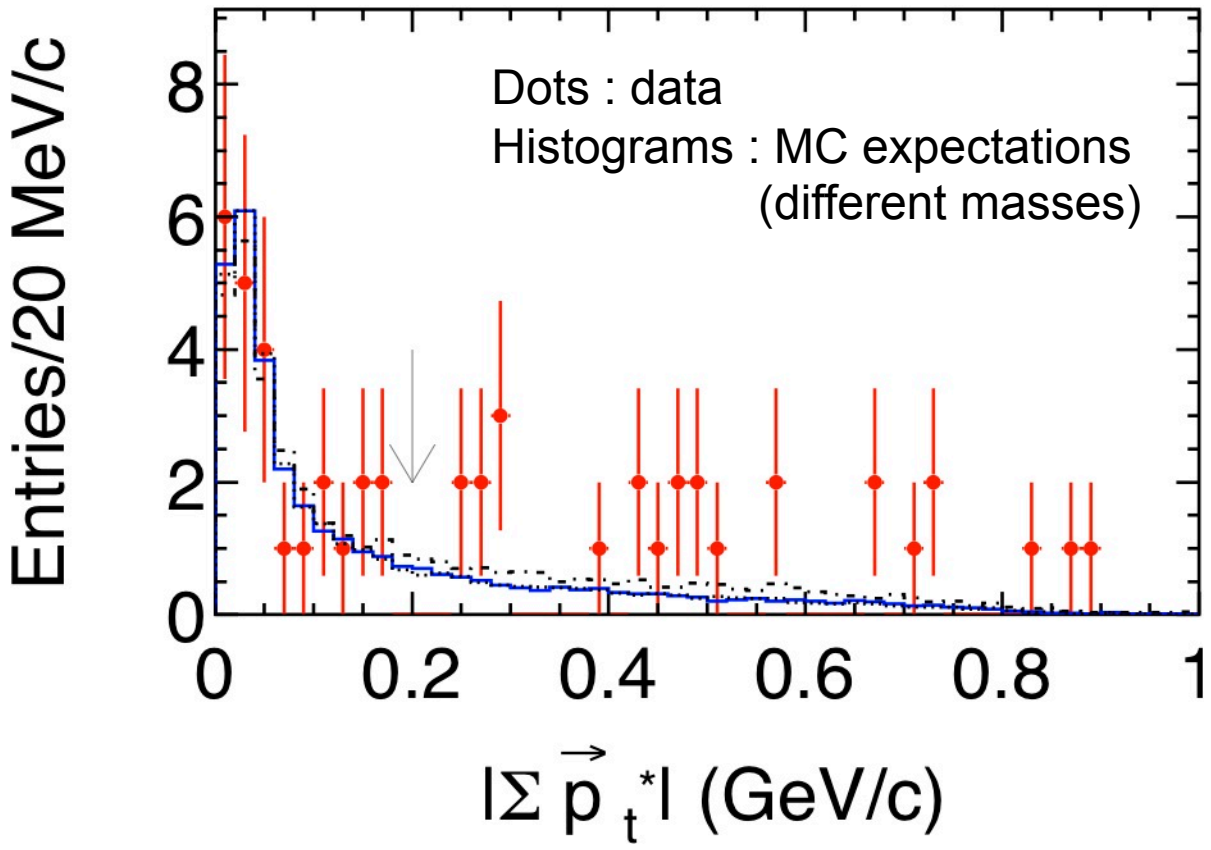
$Br(B^{\pm} \rightarrow Y(4140)K^{\pm}) \times Br(Y(4140) \rightarrow J/\psi\phi) < 6.0 \times 10^{-6}$ at Belle
$Br(B^{\pm} \rightarrow Y(4140)K^{\pm}) \times Br(Y(4140) \rightarrow J/\psi\phi) = (9.0 \pm 3.4 \pm 2.9) \times 10^{-6}$ at CDF

Note : $B^{\pm} \rightarrow J/\psi\, \phi\, K^{\pm}$ at CDF/Belle



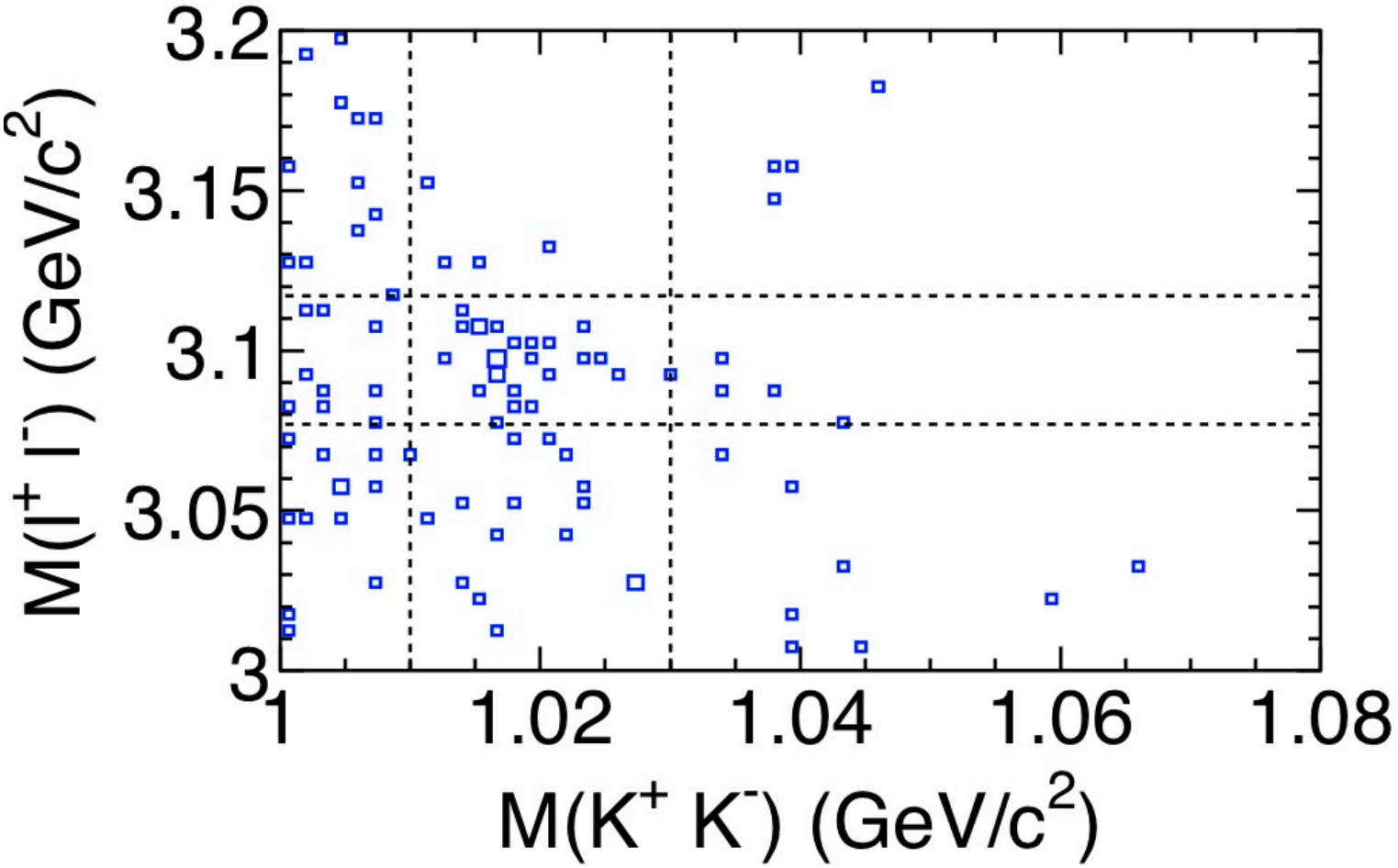
Note: CDF and Belle do not contradict each other.
In Belle, B meson at rest on $\Upsilon(4S)$ rest frame, Kaon momentum from ϕ decay is low, especially just above $J/\psi\phi$ threshold
$\rightarrow$ lower reconstruction efficiency.

J/ψ φ in γγ collision at Belle



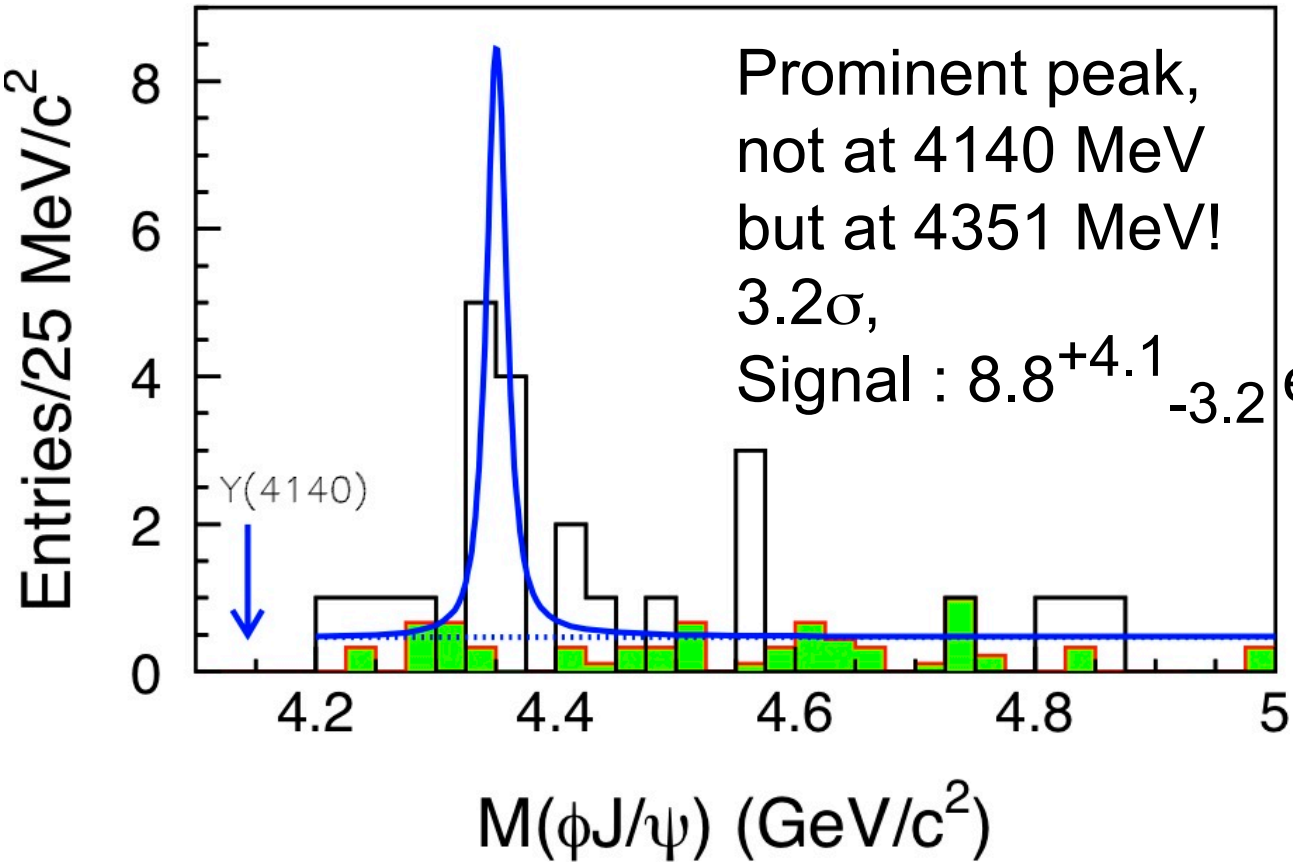
Events having a J/ψ φ combination are seen in γγ collision signal P_t region.

J/ψ φ in γγ collision at Belle



Clear peak in both projections to M(l^+l^-) and M(K^+K^-) at J/ψ and φ, respectively.

M(J/ψ φ) in γγ collision at Belle



M=4350.6 +4.6/-5.1(stat) ±0.7 MeV

Γ=13 +18/-13(stat) ±4 MeV

PRL104,112004(2010)

Summary

- Search for or observation in different production processes for the same particle will give us important information about its quantum numbers.
- M=3915MeV enhancement in M(J/ψ ω) discovered in $\gamma\gamma$ collision. B$\rightarrow$J/$\psi\omega$K to be revisited by Belle full Υ(4S) luminosity, 772M BB.
- In $\gamma\gamma$ collision, not 4140 MeV but the 4350 MeV enhancement in M(J/$\psi\phi$) evident.